Engineering Journal issn: 0125-8281

Article

Removal Performance of Silica and Solid Colloidal Particles from Chalcopyrite Bioleaching Solution: Effect of Coagulant (Magnafloc Set #1597) for Predicting an Effective Solvent Extraction

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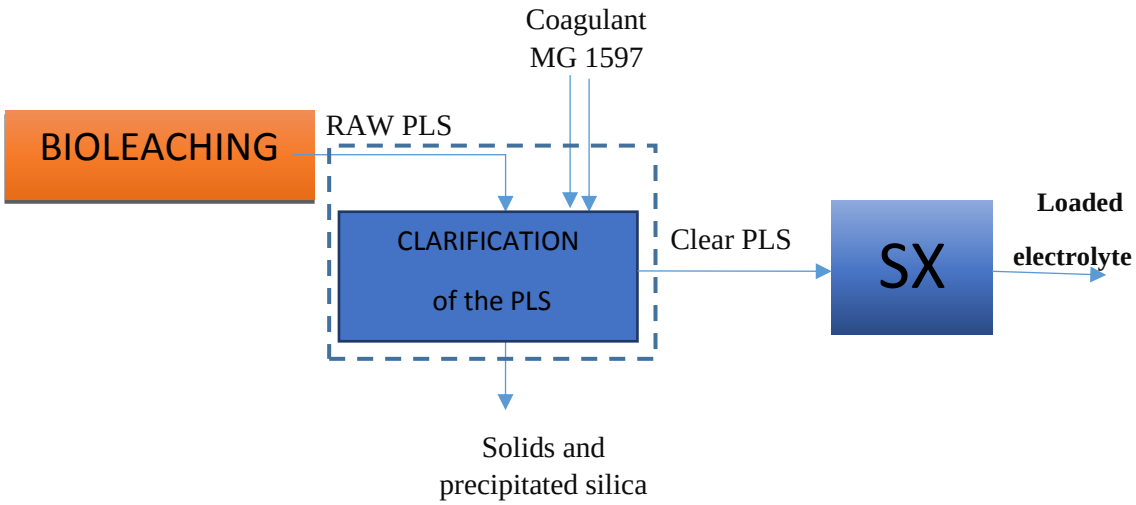
Abstract. Silicon dioxide is a compound containing two of the most abundant elements in Earth's crust. One of the main obstacles for upright solvent extraction in a copper (bio)-hydrometallurgical production chain relates to the high silica content and solid colloidal particles in the pregnant leach solution (PLS) during the treatment chain. This study assesses by way of laboratory tests the removal performance of silica and fine colloidal particles in the bioleachate solution. Their concentration requirement at solvent extraction stage could not exceed 500 ppm and 75 ppm respectively. The contact time and three ratios (coagulant/PLS): 1/2; 1/1 and 1/3 settled. The removal method from coagulation with Magnafloc (set #1597) was performed by varying its concentration in contact with the bioleachate solution. The coagulation tests consisted of finding optimal conditions with the coagulant from 0.50 to 1000 ppm, while outcomes related to the interaction of bioleached solution with coagulant consisted of the search for the optimal ratio (volume ratio). From the above, the outcomes of coagulation tests revealed a removal optimisation of silica and solid colloidal particles from bioleachate solution, which has to be greater than 200 ppm, either 300 ppm and up, keeping a volume ratio of 1/1, for a recovery rate of 68% and 58% respectively for a removal efficiency of SiO_2 and solids in suspension. A reduction of the phase separation time in aqueous continuity was observed from 230 to 148 seconds. It can be noted from the results mentioned above that the removal method will promote an effective copper solvent extraction stage, affecting the operating cost and greener environment with the possibility for recycling the organic wastes.

Keywords: Magnafloc 1597, silica, solid colloidal particles, solvent extraction, bioleachate solution, chalcopyrite.

ENGINEERING JOURNAL Volume 22 Issue 5
Received 25 January 2018
Accepted 18 July 2018
Published 30 September 2018
Online at http://www.engj.org/
DOI:10.4186/ej.2018.22.5.123

DOI:10.4186/ej.2018.22.5.123

Graphical Abstract



LX: Leaching
SX: Solvent extraction
PLS: Pregnant leach solution

PDT: Phase disengagement time

TSS: Total solids in suspension
Rpm: Revolution per minute
Rdt or Rec: Yield of the operation
AC: Aqueous continuity
CA: Continuity in aqueous phase
OC: Organic continuity
CO: Continuity in organic phase

DOI:10.4186/ej.2018.22.5.123

1. Introduction

The question is, why are scientists (metallurgists/chemists) continuing to use hazardous chemicals for recovering metals in the twenty-first century? The new challenges of this century are to promote green industry and to promote sustainable development to protect the future generations. The use of bio-hydrometallurgical aspects is one of the major assets related to the relevant technologies [1]. However, it known that a typical copper bio-hydrometallurgical proceeding consists of a bioleaching process, giving a pregnant leach solution (PLS) with various metals contained in the ore, a solid liquid separation of residues and a solution rich in copper (decantation), purification, to separate the various metals and, finally, precipitation of the base metal in a metallic state by electrodeposition (EW). Indeed, solvent extraction (SX) of nonferrous metals from a broadly acidic aqueous solution is characteristically achieved by means of a hydroxyoxime extractant [2, 3, 4, 5]. This signifies that copper SX was often selected to process oxide ores, which were considered to be waste [6, 7].

Recently, the sulphide ores were discovered to also be bioleached in the presence of acidophilic microbiota. This finding led to an ample portion of the worldwide copper production being changed to SX-based routes, with a sense of balance regarding primary sulphides being concentrated and ready for smelting (intensive energy). Plenty of expertise and machinery has been established for the conventional leaching of recalcitrant sulphide ores. Unfortunately, this is not cost effective and has more of an ecological footprint [1]. Furthermore, sulphide or oxidised copper ores are constituted in their global matrix with silicate gangue-bearing ores, clay ores, feldspar (K Al Si_3O_8) or biotite H_2K (Mg, Fe), 3Al $(SiO_4)_3$) solution of ions such as Cu^{2+}, Al^{2+}, Mg^{2+}, Fe^{2+} and K^+. It is observed concomitantly that the silica passes into the solution in colloidal form. The latter has experienced an increase in the concentration of sulfuric acid and colloidal silica in the solvent extraction process.

Because of loaded electro-negativity at the surface and suspension stability, colloidal silica does not sediment. It polymerises according to the temperature and the nature of the medium. The silica hydrolysed during the polymerisation can precipitate in the form of "emulsion stables" at the interphase during solvent extraction. The presence of this crud organic interface, in or on the surface, reduces the useful volume of the settler, which can increase turbulence and cause losses during the organic phase by entrainment within the electrolyte and/or raffinate. If the cruds begin to migrate from one stage of the circuit to another, this scenario happens because of the contamination of the electrolyte [8, 9, 10].

Several research works have reported on copper extraction [11, 12], but limited data have been gathered on methods of monitoring cruds or minimising the crud formation mostly using organic reagents to meet the relevant requirement of green and clean separation technology for environmental liabilities and sustainable development [13].

This paper, therefore, proposes a possible method to substantially minimise the harmful effects of these two impurities (silica gel and solid colloidal particles), a solvent from a copper bioleachate as well as reduction in the time of disengagement of the phases.

2. Materials and Methods

2.1. Sample Collection and Methodology

The chemical and mineralogical analysis of our bulk sample was performed using instrumental analysis methods. The bulk sample, which was leached in the presence of native mesophilic strains originating from the sulphur and iron bacteriogenic rock sample used in this work, was collected in DR Congo (Kamoa orebody). The X-ray diffraction (XRD), Atomic absorption spectrometry (AAS), Fourier transform infra-red(FTIR) and X-ray flurioresence (XRF) data confirmed that the rock sample was broadly constituted with a silica matrix bearing copper in the form of chalcopyrite with a great amount of silica, as mentioned below. XRD analysis was employed for qualitative examination of the two samples, and the profiles compared with those published in literature related to Katanga Copperbelt mineralisation. Identification of minerals in the bulk samples was achieved substantially and with a careful approach regarding the peak position and intensities in comparison with the spectra from drafted powder diffraction data for minerals and/or powder diffraction search minerals. The FTIR analysis confirmed the results as mentioned below. Some characteristics of the coagulant and wash/diluent were designed by atomic absorption spectrometry (AAS) and induction coupled plasma spectrometry (ICP). The SEM-EDX analysis of the procedure used in this

work is the classical method found in several works of literature. Additionally, we opted to use the coagulant Magnafloc 1597 with the properties mentioned below.

2.2. Properties of Coagulant, Diluent and Copper Bioleachate Solution

The preparation of the coagulant used for solid colloid removal study is the Magnafloc set #1597 manufactured by BASF (MG1597). The characteristics of the further coagulant are summarised in Table 1.

Table 1. Characteristics of coagulant Magnafloc 1597.

Name of coagulant	Physical state	Initial concentration	Dilution rate
Magnafloc 1597	Liquid	50%	0.01%

The optimal conditions of the coagulant, as well as the determination of the rate of total solids in suspension, have been performed as per conventional protocols, as observed in many works of literature. On the other hand, the characteristics of the bioleachate solution, which related to the coagulant, are indicated below as per the results obtained. The operating conditions set during the coagulation tests are as follows: settling time 45 minutes; variation of the dose of Magnafloc #1597: 0; 50; 100; 150; 200; 250; 500 and 1000 ppm; PLS volume: 500 ml; shaking operations: 150 rpm before the addition of the coagulant dose and 80 rpm after the addition of the coagulant. Shaking operations: 150 rpm, during 15min, for destabilising fine particles and silica that are in the PLS which will be fed at SX. The impact of PLS treatment with MG1597 on phase disengagement time in both continuities will be also observed in this work approach.

Some calculations:

The calculation of total solids in suspension (TSS)

$$TSS\left({}^{mg}/_{L}\right) = \frac{(m1-m0).10^{6}}{V} \quad (1)$$

m_0: mass of the filter paper, in grams (g);
m_1: mass of filter paper and the dried residue, in grams;
V: the volume of the sample to be measured, in millilitre (ml).

Depending on the nature of the solid colloidal particles and their interaction with the aqueous solution, i.e. their cations exchange. According to the Schulze-Hardy theory, the efficiency of coagulation C is proportional to the Z valence of the cation [14]. Expressed as:

$$C = kZ^{-6} \quad (2)$$

with
C: effectiveness of coagulation;
Z: valence of the cation;
k: proportionality constant.

In general, for the coagulant to disperse in the aqueous solution and obtain a homogeneous distribution before any precipitation of hydroxide requires strong agitation over a short time or, in other words, using a very high-speed gradient. In a turbulent regime, the velocity gradient is defined by the formula:

$$G = (P\ V)^{1/2} \quad (3)$$

with
G: average speed gradient (S-1);
P: dissipated mechanical power (W);
V: volume occupied by the fluid (m^3);
μ: dynamic viscosity (Pa.s).

Aggregation is done through three successive phenomena: hydrolysis (formation of metal hydroxide radicals), coagulation and flocculation [15].

The zeta potential remains negative as the general charge of colloids. It gives the level of mutual interaction of colloids and is measured by electrophoresis [15].

$$pZ = k.\ \mu\ \varepsilon.\ me \tag{4}$$

with
pZ: zeta potential (V);
k: function of the diameter of the particle and the thickness of the double layer;
μ: dynamic viscosity (Pa.s);
ε: dielectric constant of the medium.

This relationship exists between electrophoresis and the zeta potential to determine the latter. A device for direct measurement of potential exists and is called a zeterameter.

3. Results and Discussion

3.1. Characteristics of the Bulk Sample

Figure 1 shows the mineralogical analysis of a silica matrix with pyrite predominance, in which copper is found in the form of chalcopyrite ($CuFeS_2$). In addition, the following minerals were present: crystal calcite, bornite, copper, cobalt silicon sulphide, magnesite, potassium carbonate cristobalite and dolomite ($CaMg(CO_3)_2$, and silica or quartz as gangue. Chalcopyrite being enclosed in pyrite and silicate, moderately than designed a solid-solution which was structurally well definite. This was not really valuable to the pure bioleachate solution. However, by grinding, chalcopyrite can be separated from pyrite and silicate theoretically [16]. It can be mentioned that silica remains the abundant mineral and a major challenge in copper hydrometallurgical processing, pyrometallurgy and even in casting [17, 18, 19]. The magnesite phase has also been identified and its presence is due to the dolomitic nature of the overall matrix [19]. Figure 2, related to the FTIR analysis, shows the evolution of wavenumbers as a function of transmittance. This confirms, as indicated, that the Al-OH and Si-O turn out to be the main functional groups observable, in the range of around 500 cm^{-1} and 1000 cm^{-1}. Intensive peaks at 1000.20 cm^{-1} were due to the Al-O-Si stretching the vibrations bond [20]. The band occurring at 796.83–777.83 cm^{-1} was caused by inter-Si-O-Si tetrahedral bands stretching with SiO_2 and the hydroxyl band of gibbsite [21, 22]. However, Table 1 shows that Si, Fe, Al, Mg and Ca were minerals that had a major presence for both campaigns. The percentages of the major components were as follows: Si, 40.09%; Fe, 27.4%; Al, 12.79%; S, 11.10%; Mg, 3.4%; Cu, 5.2% and Ca, 0.42%. The presence of cobalt was low, but this does not mean that there is no cobalt inside the Kamoa mineralisation sector. This is due to the complexity of the Kamoa mineralisation, because cobalt is normally extracted as a by-product of copper. The high presence of silica and iron might have hindered the extraction of copper, however, this work focused attention on dealing with the silica content and solid colloidal particles after a simple iron removal.

DOI:10.4186/ej.2018.22.5.123

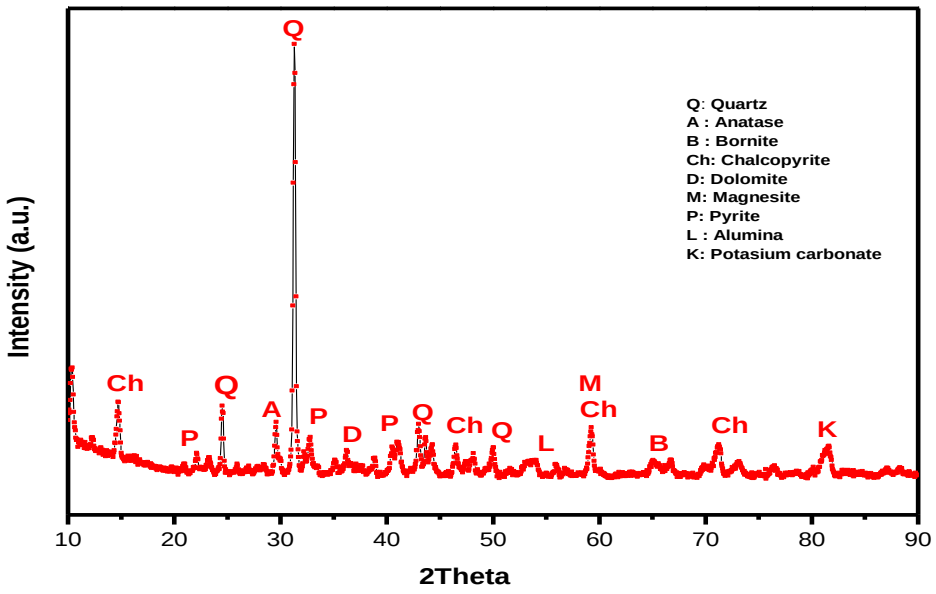


Fig. 1. The matrix model of dolomitic-siliceous pyritic bearing copper sulphides.

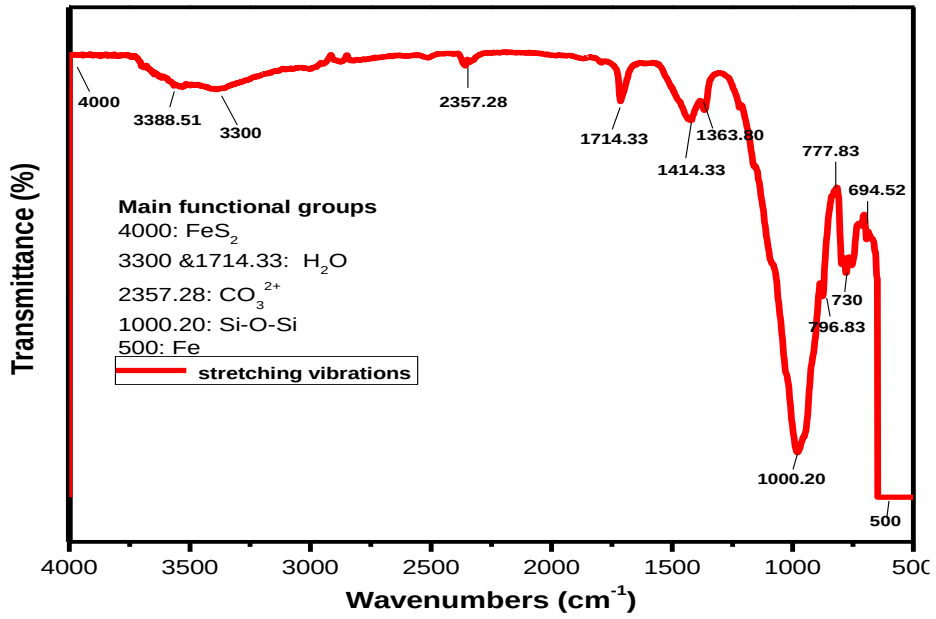


Fig. 2. Evolution of wavenumbers as a function of transmittance.

The XRF outcomes in Fig. 3 show the chemical composition.

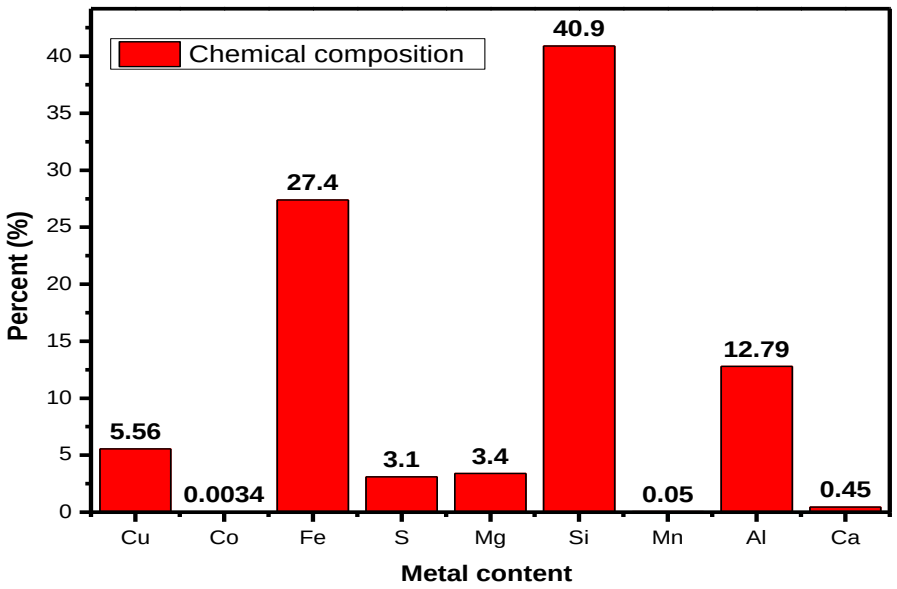


Fig. 3. Chemical composition.

This Table 2 mentioned shows the chemical composition of the bioleachate solution used.

Table 2. Characterisation of the bioleachate solution.

Metal content	Cu	Co	Fe	SiO_2	TTS
Per cent (mg/L)	14904.08	0.001	654	1634.6	168

3.2. Effect of the Dose of M1597 on the Precipitation of Colloidal Silica

The results related to the chemical analysis of the samples taken from the clarified solutions with the different doses of MG1597 coagulant are given in Figs. 4 and 5.

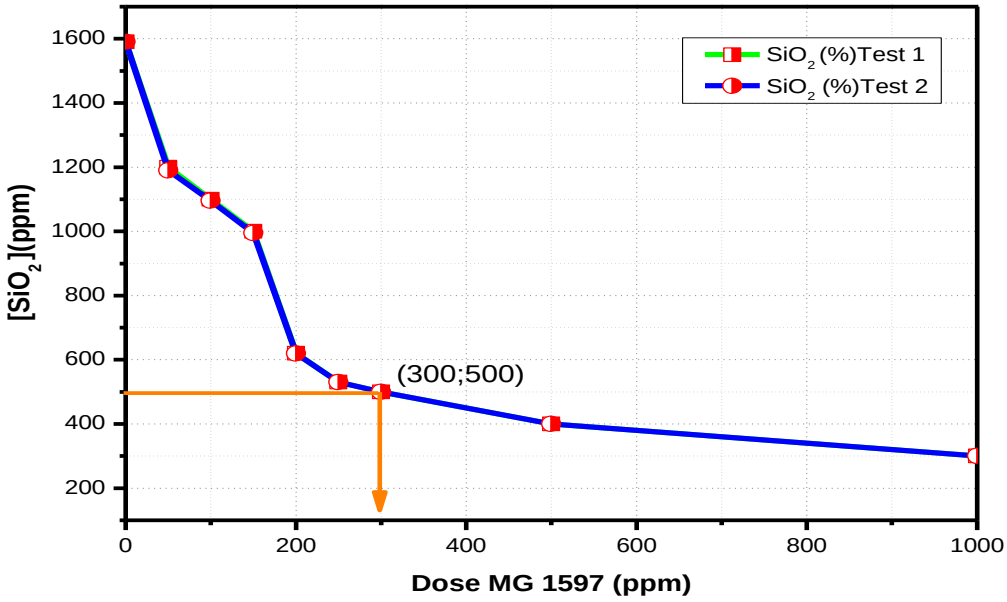


Fig. 4. Effect of coagulant dose on SiO_2 precipitation in PLS (SX1).

DOI:10.4186/ej.2018.22.5.123

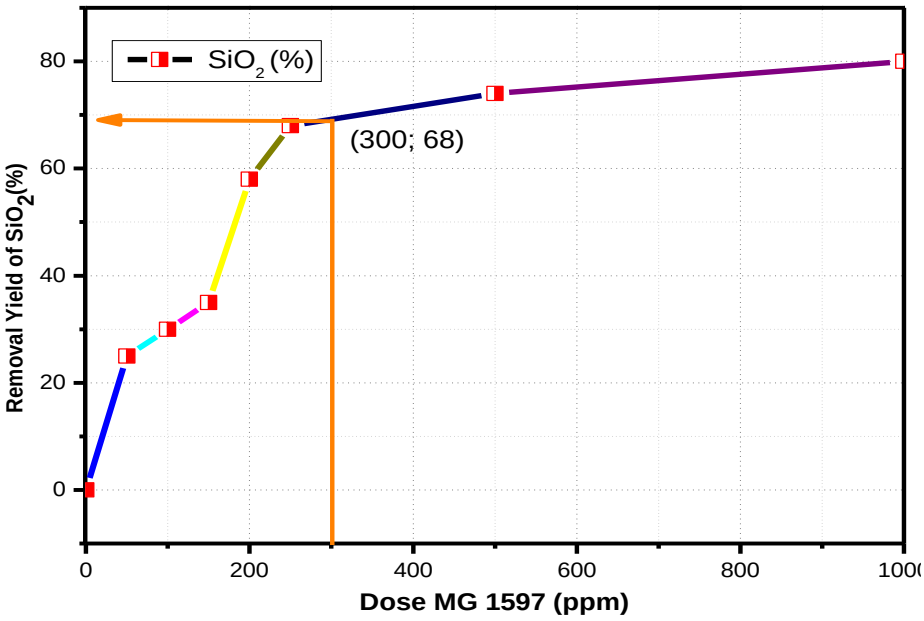


Fig. 5. Curve showing SiO_2 removal yield versus dose of MG1597 coagulant.

When carrying out the clarification operations, a clear liquid is normally expected, liberating suspended particles. By observing the results of Figs. 4 and 5 from parameters set during the coagulation tests, it can be noted that the concentration of the colloidal silica in a fertile solution does not decrease, even after a settling time of greater than 10 minutes when no coagulation agent is used, with a dose of 0 ppm of MG1597, the total amount of silica is found in the overflow after 45 minutes of settling. From the theory seen in the first part of this work, it is believed that, in the presence of a silica, which is in colloidal or dissolved form, as the dose of MG1597 increases, the silica content in the treated solutions decreases further, reaching concentrations of less than 500 ppm, the maximum concentration at which silica starts to make a problem SX. The work carried out by references [23, 24] proposes that the cruds formation leads to decreased washing effectiveness, lower phase dislocation, commotion of the interfacial monitor at the settler of the extractor, and so on. In Fig. 4, the curves (Test 1, Test 2 and Test 3) show the tendency of solutions after treatment of PLS at different doses of MG1597. The three curves are similar, and their paces are such that, at low doses of the coagulant, a significant decrease in colloidal silica up to the dose of 250 ppm (dose precipitating 1020 ppm of SiO_2) is reported. Beyond this dose, the curves tend to become rapidly parallel to the abscissa axis, so there is no more significant improvement beyond this dose. By making the intersection of the line $y = 500$ with the mean of the curves Test 1, Test 2 and Test 3 (Fig. 4), we find the point (300; 500). These coordinates mean that a minimum of 300 ppm of MG1597 is required for the concentration of silica remaining in the PLS to be 500 ppm. According to references [25, 26], Silica in all its forms tends to cause a slow phase separation, generates an instability of the phases and increases the formation of cruds. The concentration from which it becomes harmful to the solvent extraction is about 500 ppm [25]. These results are substantial, taking into account the coagulant concentration used that will affect the operating cost and the related environmental cost in relation to the process used. Thus, these results compared the studies carried out by reference [27], who obtained an effective silica removal yield (80–90 %) by adding soluble magnesium compounds (1500 ppm) to the effluent. Additionally, they found in 2013 [28] that, using aluminum salts (2500 ppm), a silica removal rate of 90% with pH control was obtained. Without pH regulation, with (2500 ppm) as the coagulant concentration, a silica removal rate of 76% was obtained with PANS-PA2. On the other hand, different earlier studies showed the addition of a coagulant to support silica removal during the softening process [29], yet, there is no agreement on whether coagulant addition noticeable increases silica removal. However, reference [30] believes that the addition of ferric chloride and aluminum salts only slightly improves silica removal through the softening process. However, it is believed that polymers can be synthesised inexpensively and without issue some by-products during polymerisation [31]. Our results are substantial because two coagulation stages can be performed with the same concentration for great results

and will never reach the concentration used by earlier studies. However, 300 ppm is an effective coagulant and fulfils the requirements.

3.3. Effect of the Coagulant Dose on the Stability of Solids in Suspension

The TSS results before and after treatments of copper bioleachate PLS by different doses of MG 1597 coagulant are presented in Figs. 6 and 7.

The graphical representation of these results shows the dose MG1597 that acts effectively on the solid particles contained in the PLS, acting either on the zeta potential of the colloidal particles or by compression of the double layer of Stern.

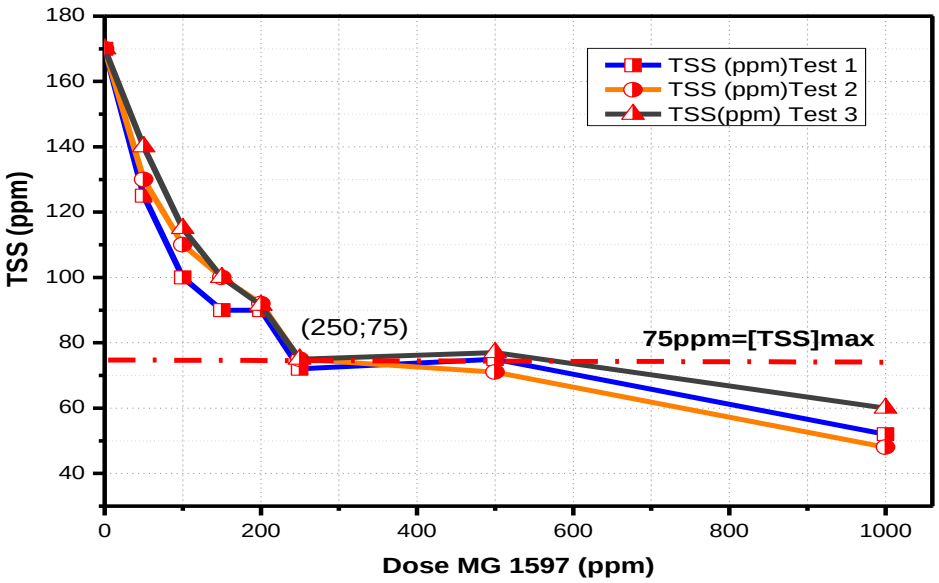


Fig. 6. Effect of MG1597 dose on destabilisation of solids in the bioleachate.

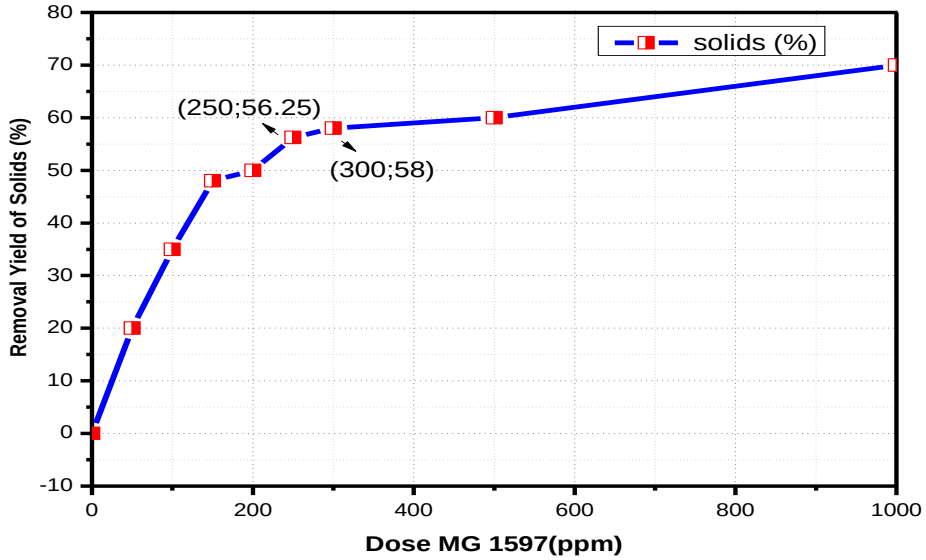


Fig. 7. Solid cumulative coil release rate of elimination of MG1597.

The PLS clarification yield changes in the same way for the three sets of coagulation tests (Figs. 6 and 7). Indeed, the solid removal efficiency increases rapidly (positive and large slope) in the dose range between 0 and 250 ppm (Fig. 6) and after 50 ppm, the slope emerges gradually however, from Fig. 6, this curve tends

to become zero when the coagulant dose increases. For example, at a dose of 50 ppm, the suspended solids remain about 100 ppm in the bioleachate solution. At 200 ppm, the figure for the total solids in suspension is 90 ppm, really close to the required limitation of 75 ppm. Finally, the point 250 ppm is assigned to exactly 75 ppm. It can be noticed that this change of slope means that it is close to the optimal dose. For minimising the related problems at solvent extraction, the rate of suspended solids can be acceptable between 50 and 100 ppm. In addition, the point 1000 ppm correlates with 60 ppm. It can be observed, comparatively, that the points with doses 250 ppm and 1000 ppm do not have a great difference in terms of outcomes. However, according to this work approach, it can be considered that the use arithmetic mean of these two values as the maximum concentration that must not be exceeded. From Fig. 7, by reasoning in the same way as in the previous point, it can be seen that 75 ppm in solid suspension corresponds with a coagulant dose of 250 ppm. So, hoping to have a solids level lower than 75 ppm in the copper bioleachate solution at the entrance of solvent extraction, the operator must use a dose of MG higher than 250 ppm. With 250 ppm of MG1597, the removal efficiency of suspended solids is equal to 56.25%. Using information in both Figs. 6 and 7. This signifies that, by using a dose of at least 250 ppm, remove 56.25% of solids from the PLS which will correspond with 75 ppm of TSS acceptable for efficient solvent extraction. In addition, as can be seen from Figs. 6 and 7, for all the coagulant doses, the TSS diminished with an increase in the coagulant dose, but rapidly started increasing up to 250 ppm. The last three coagulant dosages stabilised the suspended matters perfectly owing to their weights. That can be explained by the reduction of the TSS in the bioleachate treated.

However, it is of interest to mention that, for coagulant doses over 250 ppm, the suspensoids removal increased arithmetically as a result of the destabilisation of the flocs formed and became steady beyond 250 ppm because of the concentration and the extent of the coagulation. This signifies that the excess in coagulant governs a compression of macromolecular chains thereby decreasing active sites where the suspended solids are adsorbed. The main parameters leading the rate of orthokinetic coagulation are the concentration of coagulant and velocity gradient and exposure time applied. The degree of coagulation is ruled by all the above-mentioned factors, which play a crucial role on the effect of macromolecular chain compression. However, the control of coagulation factors is indicated more for efficient coagulation. Furthermore, three scenarios can occur at copper solvent extraction if the TSS is higher than required: (a) an upsurge in phase disengagement times; (b) reduced capacity of the organic hydrophobicity; and (c) lessened coalescing facilities related to the organic phase due to the formation of cruds. It is also of interest to remember that the bioleachate solution before treatment contained 168 ppm of TTS. Compared with studies carried out by reference [32] relating to the of highest TSS removal efficiencies of PAC, FS, and FC respectively different commercial coagulants gained, at 2 g/L of coagulant added, a removal yield of 38%, 38%, and 47% respectively. According to the findings of the studies led by [33], the maximum performance for TSS removal that was gained at a 2.5 g/L dose of PAC, by alum at 1.5 g/L dose of FS at 2.5 g/L dose of FS, were 39.14%, 58.37% and 35.58% respectively.

3.4. Effect of Coagulant Dose, Silica [SiO_2] Concentration and Solids Content (TSS) on the Phase Separation

The experimental results of the phase disengagement tests performed before and after the coagulation tests are given in Figs. 8 and 9.

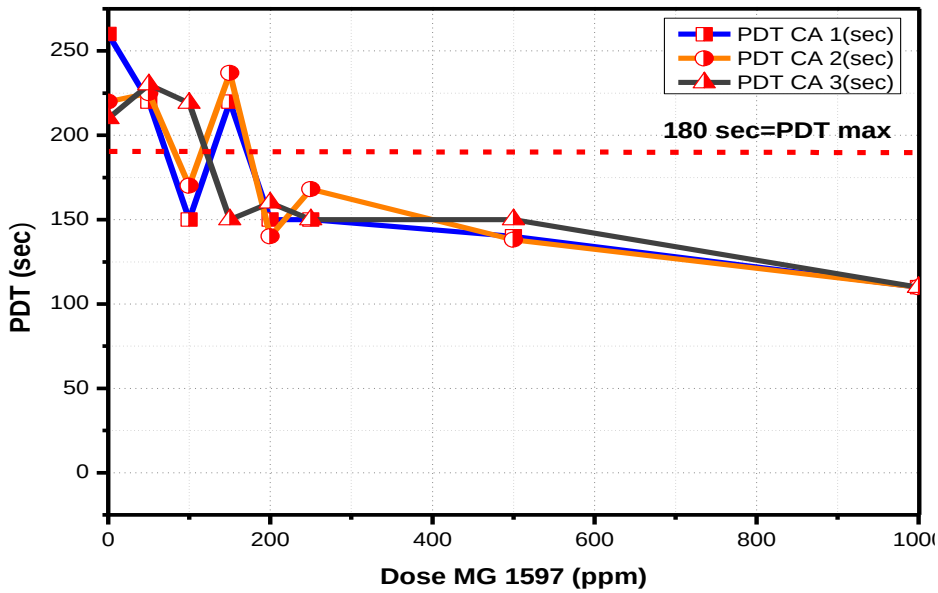


Fig. 8. Effect of the MG1597 dose on the disengagement of aqueous continuity phases (CA PDT).

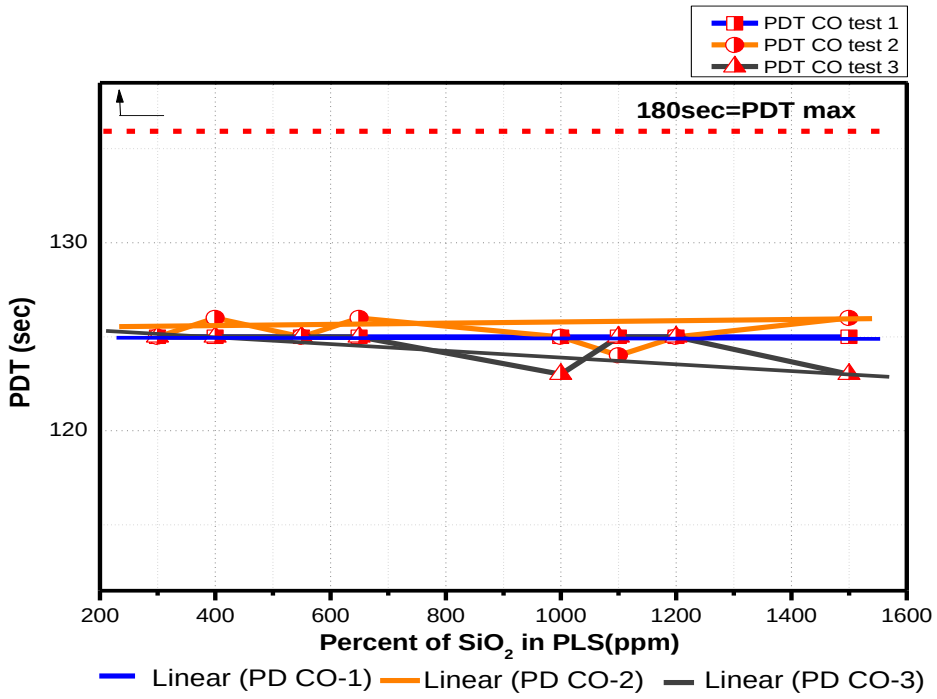


Fig. 9. Effect of colloidal silica concentration in PLS on organic continuity disengagement.

Analysis of the results identify a decrease in the phase disengagement time with an increase of the coagulant dose in the two continuities, but this decrease is visible in the aqueous continuity. The phase separation time in the aqueous continuity decreases with the decrease of silica content in the aqueous phase (Fig. 8). The presence of silica in bioleachate does not significantly affect the disengagement of phases in organic continuity (Fig. 8). The solids content in the PLS has a much greater effect on the phase separation time in the aqueous continuity than in the organic continuity. This observation is in accordance with the work performed by [34, 35]. Indeed, for a lengthy period, a high solids content in the PLS (Fig. 8, Fig. 9) was reported. Already observable at 105 ppm in the PLS, the solids in suspension start to slow the phase separation and the time exceeds the 180 seconds recommended for good operations during the solvent extraction. Furthermore, by comparing the figures taken in pairs, or the pairs (6 and 7) and (8 and 9), it is

noticed that the shape related to the corresponding curves is similar. It can be confirmed that fine particles in suspension and colloidal silica contained in the aqueous phase are also responsible for the slowing down of phase separation to solvent extraction. However, our findings compared with studies carried out by [36] with a pregnant leachate solution containing 2000 ppm of TSS by using rheomax® DR 1050, senfloc® 2660 and brontë 103 respectively. It was noted that, under optimal conditions, set flocculant /aqueous or ratio of 1.5 with a a dose of flocculant of 116.28 g/t, the residual concentrations of total suspended solids in the leachate solutions were 1196 ppm, 928 ppm and 954 ppm respectively. The phase disengagement times (PDT) for organic continuous diffusion were 70, 60 and 80 s respectively. They noticed that copper recoveries were 97.63%, 95.13% and 98.98% with rheomax® DR 1050, senfloc® 2660 and brontë 103 respectively. It can be noted that in their studies, the low residual suspensoids were referred to be low 1000 ppm (working industrial conditions) but not the norms as mentioned above (≤75 ppm) and ≤50 ppm [36]. This difference with our findings is also related to the physical characteristics of the TSS and the paradigm of the required concentration for TSS removal. The comparison of our findings with those of reference [36] shows that their results are still critical, based on cruds formation, which can occur after solvent extraction (stripping and electrowining) depending on the TSS and silica concentration required for efficient SX. However, their phase's disengagement time were better than the phase disengagement time obtained in our experiment. Additionally, both PDT were in the time required as per the norms, which must not be longer than 3 minutes in general. The medium 120 minutes and the least 60' [37].

3.5. Effect of Temperature on Phase Separation in Aqueous Continuity and Phases Ratio

The curves that are presented in Fig. 10 were obtained by combining the collected experimental data.

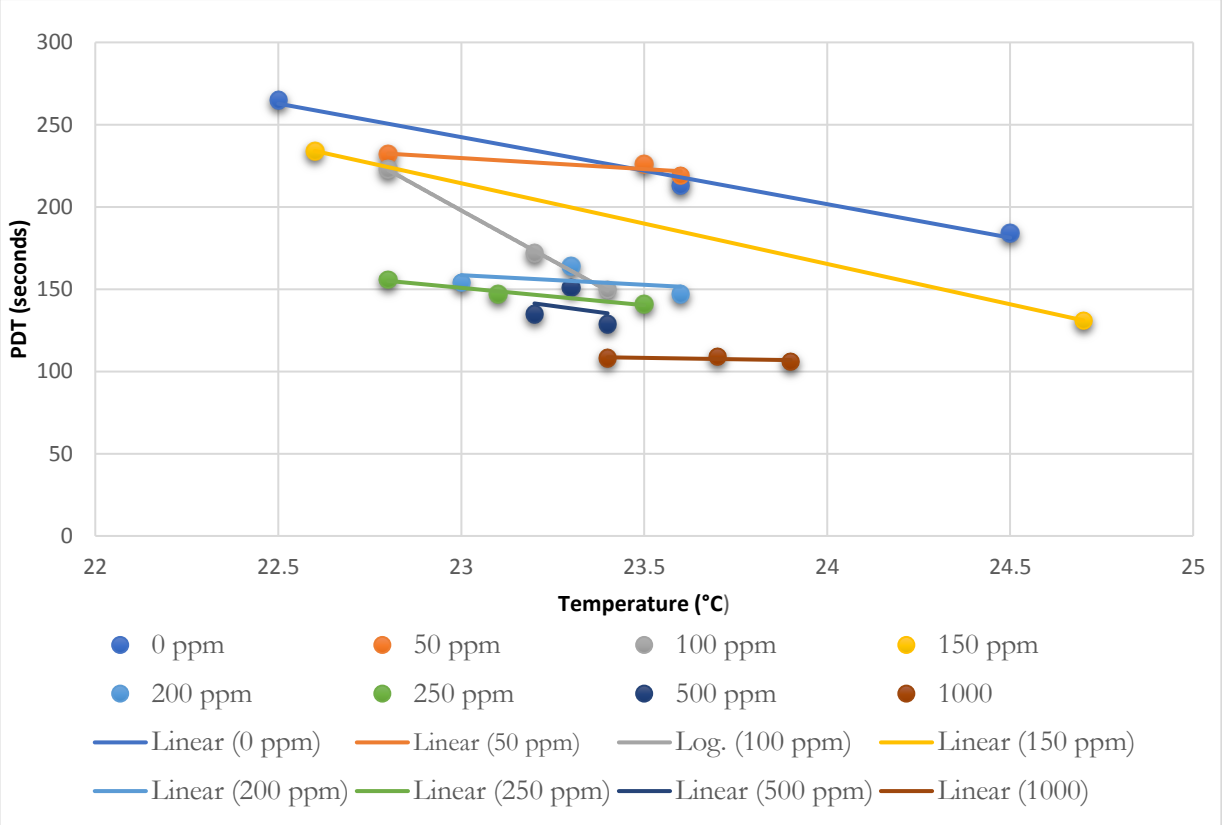


Fig. 10. Effect of temperature on phase separation in aqueous continuity.

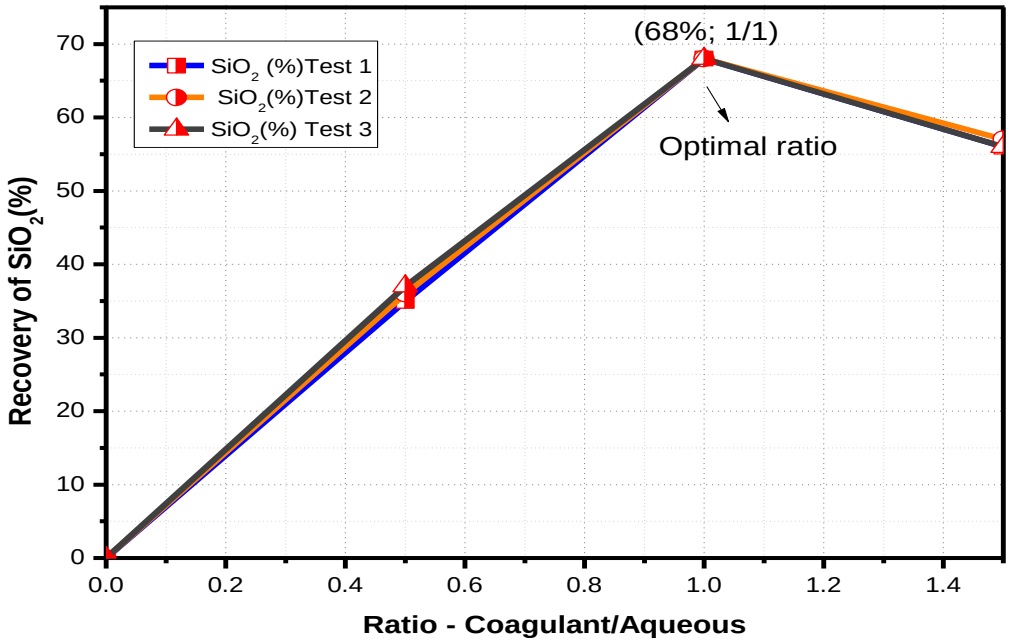


Fig. 11. Effect of coagulant: aqueous phase ratio on the removal of silica from aqueous solution. MG 1597 (300 ppm).

Figure 11 shows the difference in phase separation time for samples that have been treated with the same dose of coagulant is noted. Indeed, these differences in terms of phase separation times can have two causes: on the one hand, the difference in silica concentrations (solids level) in the various samples [38], and, on the other hand, the difference in temperatures during the solvent extraction. Figure 10 shows how higher temperatures involve a short separation of the phases, i.e. the viscosity of the mixture decreases with increasing temperature. By extrapolating the data, too short phase disengagement times by solvent extraction at temperatures above 25 °C can be predicted. Figure 11 shows that the phases ratio of 1/1 with 68% of silica removal with the coagulant dose of 300ppm was the best compared to the phases ratio of 1/2 and 1/3. This observation is in accordance with the studies carried out by several authors [39, 40]. This signifies that the intensification of the hydrophobic exchanges due to phase ratio reasons an increased zeta potential values with a certain phases ratio which affect the destabilisation of silica.

4. Performance Analysis

Performance analysis enabled assessment of the technical performance, which was provided in this work. Table 3 compares the performance of MG 1597 coagulant on the clarification of PLS in terms of yield.

Table 3. Comparison of the performance of MG 1597 coagulant.

#	Criteria	Treatmentwith MG1597
1	Yield of silica removal from bioleachate (%)	68 > 50% [SiO_2] < 500 ppm
2	Recovery of colloidal solids (%)	58.82 > 50% [TSS] < 75 ppm
3	Enhancement of PDT in AC (at 25 °C)	From 245 to 144 seconds Either (144 < 180 seconds)

DOI:10.4186/ej.2018.22.5.123

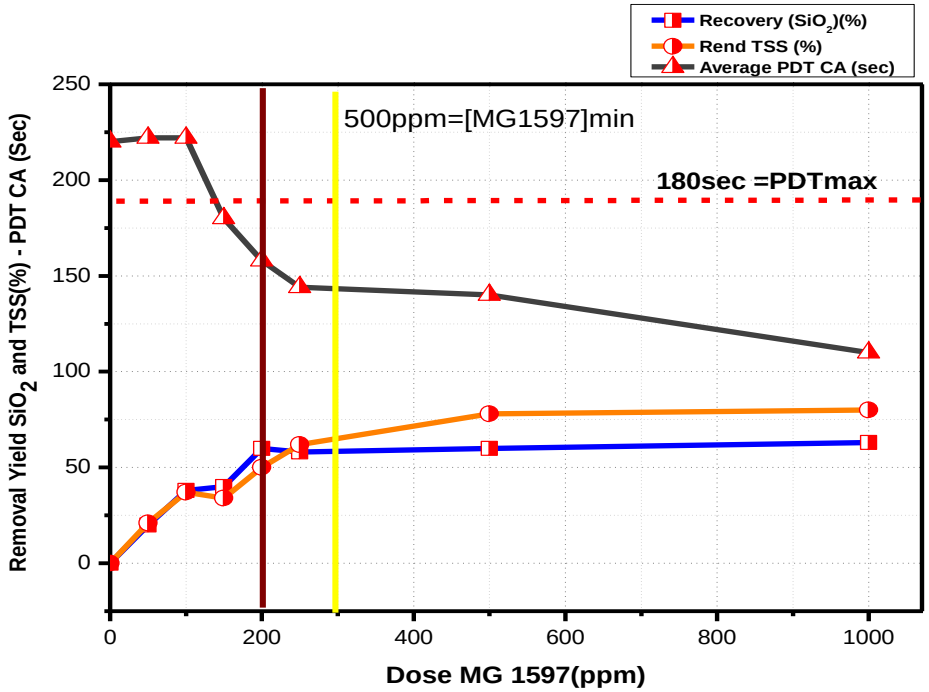


Fig. 12. Superposition of curves (Rdt SiO_2, Rdt TSS and PDT AC as a function of dose MG1597) with limited values.

Figure 12 shows in a nutshell, the results of all the figures in this work. It is a superposition of the graphs presented in the coagulation part. It allows defining of the area in which we must work to minimise the effects of silica and fine particles. The optimal dose is found in this area and it will also depend on economic parameters. It will be retained at the end of this study of destabilisation of suspended particles using coagulant as MG1597 that deals with silica and solid colloidal particles, which is in two forms: the dissolved form and the colloidal form [36]. The coagulation tests shed light that, each time varying the dose of the coagulant, the problem related to the colloid clearance could be solved largely by treating PLS with the coagulant and with a dose of MG1597 greater than 250 mg/L, as per the rating requirement for effective solvent extraction: a solids content in suspension of less than 75 ppm in the aqueous phase; a content of less than 500 ppm in the copper sulphate solution. A phase separation time of less than 180 seconds in phase's continuity. Figure 13 shows the pollution of cathodic copper from polymerisation reaction originated from colloidal particles and silica present into pregnant leach solution at copper solvent extraction.

Fig. 13. Physical aspect of cathodic copper when solid colloidal particles and silica are present in aqueous solution at copper solvent extraction

5. Conclusion

The purpose of this study was to propose a method that could reduce silica and colloidal solid particles impurities contained in the copper bioleachate solution, because this poses several challenges for post-leaching operations (solvent extraction-stripping and electrowining) in mining factories.

Several jar-tests were carried out to determine an optimal destabilisation dose of these fine particles. The dose of Magnafloc 1597 coagulant was varied between (0–1000 ppm) while the settling time remained fixed throughout the tests, i.e. 45 minutes. The results of these tests showed that the coagulation technique has been effective in reducing impurities and therefore reducing the phase separation time with 250 ppm of Magnafloc 1597 effectively reduced the disengagement time from 230 seconds to 180 seconds in aqueous continuity. So, any dose greater than 100 ppm of Magnafloc 1597 will bring this time into the set point margin.56, 25% of suspensoids have been removed and 68% of silica. It can therefore be suggested to treat the bioleachate solution by carrying out pilot scale tests as well as an economical assessment of the removal technique is recommended in order to make a substantial approach for further consideration.

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